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Indian Standard

GUIDANCE FOR ENVIRONMENTAL TESTING

PART VIII SEALING TEST

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GUIDANCE FOR ENVIRONMENTAL TESTING

PART VIII SEALING TEST

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GUIDANCE FOR ENVIRONMENTAL TESTING

PART VIII SEALING TEST

0. FOREWORD

0.1 This Indian Standard (Part VIII) was adopted by the Indian Standards Institution on 29 January 1982, after the draft finalized by the Environmental Testing Procedures Sectional Committee had been approved by the Electronics and Telecommunication Division Council.

0.2 This standard (Part VIII) covers guidance details for the sealing test. The test procedure for sealing test is covered in IS : 9000 (Part XV)-1982*.

0.3 In preparing this standard, assistance is derived from the following:

IEC Pub 68-2-17 (1978) 'Basic environmental testing procedures. Part 2: Tests — Test Q: Sealing'. International Electrotechnical Commission (IEC).

JSS 55555-1977 'Environmental test methods for electronic and electrical equipment'. Directorate of Standardization, Ministry of Defence, India.

0.4 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960†. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard (Part VIII) deals with guidance in performing various sealing tests as applicable to electronic and electrical items.

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*Basic environmental testing procedures for electronic and electrical items : Part XV Sealing test.

†Rules for rounding off numerical values (*revised*).

2. GUIDANCE TO CONTAINER SEALING, GAS LEAKAGE

2.1 Applicability of Test

2.1.1 The test is suitable for the detection of leak rates greater than 10^{-4}, 10^{-5} or 10^{-6} Pa.m^3/s according to the method chosen.

2.1.2 Test Methods 1 and 3 are applicable only to items that are able to withstand full decompression without enduring distortion or permanent physical damage (*see* **2.2**, **2.3** and **2.4**).

2.1.3 Test Method 2 is applicable to all items, subject to a significant thermally generated pressure differential being achieved at the maximum ambient temperature of operation of the item.

2.2 The information derived from this test is only of a semi-quantitative nature, indicating individual leakage paths and not the total leakage associated with the item.

2.3 When using the optimum test conditions, Test Method 1 can achieve a sensitivity of 10^{-5} Pa.m^3/s; Test Method 2 : 10^{-4} Pa.m^3/s; and Test Method 3 : 10^{-6} Pa.m^3/s. Varying severities can be achieved with Test Methods 1 and 2, by utilizing different levels of vacuum and test liquid temperature, respectively. However, it should be borne in mind that some components may be damaged by subjecting them to overpressure or underpressure.

2.4 With Test Method 1, a pressure differential of 100 kPa can be achieved whereas Test Method 2 will produce a pressure differential in the range 12 kPa (55°C) to 36·5 kPa (125°C). Consequently, increasing the immersion time of Test Method 2 to 10 min should produce an approximate equivalence in severity with Test Method 1.

NOTE — It should be noted that once temperature stability (between the item under test and test liquid) is attained, no further increase in sensitivity would occur with increased duration of immersion. The increase may occur only in the case of items with greater thermal mass.

2.5 Items having seals on more than one surface require each surface to be tested separately. Consideration should be given to the possible need for recovery of the item prior to the testing of each surface, for example, items having a small included gas filled cavity could have this exhausted during the testing of one surface.

2.6 Observation should be made against a dull, non-reflective black background, under direct lighting adjusted to provide maximum visibility at the item position, through a 3 × magnifier or stereo-zoom microscope arranged for observation of bubbles emanating from the items immersed in the liquid.

2.7 With certain types of items, engineering judgement will be required to distinguish between 'real' and 'virtual' leaks, because of the gas retention capability of the material. In most instances the rate of bubbles and/or growth of bubble issuing from a virtual leak will decrease as the source of gas is exhausted. It may also be suggested that a dummy item consisting of a solid block of the same material is used for comparison purposes.

2.8 Items should be as clean as possible and free from foreign material on the surface, including coatings and any markings if they may contribute in erroneous test results. Careful handling is also required to avoid contact of bare fingers with critical parts of the item.

Test liquids should be chosen so as to behave in a stable condition throughout the test.

2.9 Test Method 1

2.9.1 For Test Method 1, the test liquid shall have the following characteristics:

Kinematic viscosity at 20°C	:	$25 \cdot 10^{-6}$ m^2/s
Kinematic viscosity at 50°C	:	$9 \cdot 10^{-6}$ m^2/s
Mass density at 20°C	:	890 kg/m^3
Ambient vapour pressure	:	<10 Pa

A suitable liquid may be oil. It should be degassed. Water with a wetting agent or any suitable liquid having a kinematic viscosity of not more than $25 \cdot 10^{-6}$m^2/s at 20°C may be used, but in this case it shall be considered that the sensitivity of the test will be impaired. The depression shall be limited by the risk of having the liquid boiling.

2.9.2 Since any initial frothing may mask bubbles due to leaks from the item sealing, it is essential that the reduced pressure in Test Method 1 be attained rapidly.

However, if the air space within the item is small or if the leak rate is large, the bubbles emerging through the sealing during the initial frothing may not be detected.

2.10 Test Method 2

2.10.1 Before selecting Test Method 2, assessment of the heating effect on the item should be considered, for example, in view of the closing and/or opening of leakage paths.

2.10.2 For Test Method 2, water with a wetting agent may be used for test temperatures lower than 90°C. For higher test temperatures, suitable liquids should have a kinematic viscosity of the order of $0{\cdot}3{\cdot}10^{-6}\,m^2/s$ at the test temperature. In the latter case, commonly used liquids are fluorocarbons, for example, perfluorotributylamine or perfluoro (1-methyl-decaline) which are available under various trade marks. The volume of the bath shall be at least 10 times the volume of the item.

2.11 Test Method 3

2.11.1 For Test Method 3, the impregnation liquid shall have a kinematic viscosity of the order of $0{\cdot}4{\cdot}10^{-6}\,m^2/s$ at room temperature, a boiling point of approximately 60°C and a low heat of vaporization at boiling point so as to quickly generate vapour within the item when Step 2 is performed. Commonly used liquids are fluorocarbons, for example, cyclicperfluorodipropyl-ether or perfluoro-N-hexane, which shall be compatible with the liquid utilized in Step 2.

2.11.2 It is recommended to filter the liquids through filter paper before use. Testing should preferably be conducted in a well-ventilated location. When partially fluorinated fluids are used, there are additional risks incurred due to contamination from moisture and dissolved greases and the possibility of damage to markings or elements of the item.

2.11.3 Some danger of explosion may exist when testing large items with Test Method 3 if the size of the leak and the combination of immersion duration and pressure are such that the device is likely to be filled up with the impregnation liquid which will vaporize very rapidly during Step 2. It shall be pointed out that such leaks can be traced by applying Test Method 2 alone.

2.11.4 Care should also be taken that no drops of impregnation liquid fall on the heating plate because poison gas may be liberated when it is boiled dry.

3. GUIDANCE TO CONTAINER SEALING, SEEPAGE OF FILLING LIQUID

3.1 Applicability of Test — This test is suitable for the detection of leak rates corresponding to an air leak rate greater than about $10^{-6}\,Pa.m^3/s$. The sensitivity of the method depends on the kinematic viscosity of the liquid at testing temperature and the technique employed to detect the seepage.

3.2 The sensitivity of the test method is influenced by the following factors:

a) The kinematic viscosity of the filling liquid. A low kinematic viscosity gives relatively high sensitivity;

b) Duration of conditioning. The quantity of seepage will be directly related to the duration of conditioning. As greater quantities of seepage are more easily detected the sensitivity of the test may be increased with test duration; and

c) Method of detection.

3.3 The most simple way to detect any seepage is by visual inspection with the naked eye. This quick and cheap method is only possible when the seeping liquid contrasts clearly in colour or reflection from the ground materials. If this is not the case then one of the following methods is recommended:

a) Cover the surface of the item around the seals with a film of suitable dust. Discoloured spots in the dust film will indicate the presence of some seepage. For instance, a film of talcum powder is especially suitable for the detection of oily liquids or a film of permanganate of potassium ($KMnO_4$) powder for watery liquids;

b) Place the item on a clean blotting-paper. Clearly visible spots will be produced by drops of coloured or oily liquids; and

c) Fluorescent liquids may be detected in ultra-violet light. This method, for example, is very sensitive for mineral oils, but fails for certain chlorinated oils.

4. GUIDANCE TO SEALING, TRACER GAS METHOD WITH MASS SPECTROMETER

4.1 Applicability of Test

4.1.1 This test is suitable for the detection of leak rates smaller than about 10^{-6}Pa.m^3/s.

4.1.2 Test Method 1 is applicable only when the items do not have surfaces likely to impair the results by too high a retention of absorbed helium (such as, braids, joints, organic materials, paints, etc) unless they have been suitably neutralized before the detection phase.

4.1.3 Test Method 2 is intended for items that have been filled, during manufacture, with a mixture containing a large proportion of helium.

4.2 In this standard the leak process is considered as corresponding to a molecular flow of gas through the leak path.

The influence of the temperature is considered negligible in the usual range of test temperatures.

4.3 The volume of vacuum chamber used for leak rate measurements should be held to the minimum practical size, as this chamber volume has an adverse effect on sensitivity limits.

4.4 In all cases, it is necessary to complete the fine leak detection with a gross leak detection, provided that there is confidence that the sensitivities of the methods employed are sufficiently overlapping. The gross leak detection is necessary because, if the leak is large enough to allow the partial pressure of helium to drop considerably during the recovery period, no signal will be obtained on the leak detector.

4.5 Engineering judgement may be required for interpreting the readings of the leak detector, especially when this reading is decreasing. It may indicate either a gross leak or an insufficient recovery period. It is often difficult to distinguish between them. A suggestion for overcoming this difficulty is to compare the signal variation versus time with that obtained with a dummy item, such as a solid block of the same material.

4.6 It may also happen that unavoidable spread in a batch of products (for example, number of bubbles in a glass seal, differences in lacquer or paint quality, retention capability of coramics, etc) results in varying amount of absorbed or adsorbed helium. In such cases the determination of real leaks may be made using the helium sniffer method or specialized humidity-bias-temperature test. Another approach is a careful study of the leak rate versus time curves: adsorbed helium shall give quickly decaying curves whereas the time constant of the exponential and the leak rate level shall usually be comparatively greater for actual leakers. In this case, the items shall be observed for longer period than specified in **6.5** and **6.6** of Section 5 of IS : 9000 (Part XV)-1982*. The reduced equation given in **A-1** of Section 5 of IS : 9000 (Part XV)-1982* may then be used but only if the observation period is negligible with respect to the time constant θ.

4.7 During the immersion phase, the partial pressure of helium in the cavity is given by:

$$P\left\{1 - e^{-\left(\frac{Ma}{M}\right)^{\frac{1}{2}} \cdot \frac{t_1}{\theta}}\right\}$$

where

P = absolute pressure of immersion, in Pa;

Po = atmospheric pressure, in Pa;

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*Basic environmental testing procedures for electronic and electrical items: Part XV Sealing test.

Ma = specific mass of air, in kg/m^3 (28·7 kg/m^3);
M = specific mass of helium, in kg/m^3 (4 kg/m^3);
t_1 = immersion time, in seconds;
$\theta = \frac{PoV}{L}$ = required severity, in seconds;
V = internal volume of the item, in m^3; and
L = equivalent (calculated) standard leak rate of air in Pa. m^3/s.

If the partial pressure of helium varies similarly for devices having different internal volumes, this implies that their filling time constants θ are identical. Hence, the acceptable performance criterion for the item could preferably be expressed in terms of filling time constant, in order to be independent of the volume of the internal cavity of the item and to effectively compare the sealing quality of different items intended for use in the same application.

4.8 Choice of the Applicable Severity

4.8.1 The concept of time constant θ will be useful to the specification writer in specifying the acceptable performance limits for an item as it directly relates to the life expectancy of the item. Unlike the concept of equivalent standard leak rate (L) the time constant θ can immediately provide an idea of the life expectancy of the sealed item even for two devices of very different volumes. For example, two items of different volumes but having the same time constant θ are likely to have a similar life expectancy. Conversely, the life expectancy of an item with θ = 600 h, shall be substantially greater than that of another with θ = 60 h, whatever may be the volume of internal cavity and immersion pressure (P) or duration (t_1). Therefore, it will be sufficient for a designer or the user of component to think and specify the performance criteria for the item in question in terms of time constant θ. This may then be expressed in terms of L for the different cavity volumes V (*see* Table 1) for the benefit of the test engineer.

4.8.2 The test engineer is allowed to choose the test parameters with the help of Table 1 and the details given in Appendix A of Section 5 of IS : 9000 (Part XV)-1982*. While choosing the immersion pressure, the mechanical resistance to pressure of the item under test shall be taken into account. A special care shall be taken when testing large flat devices. The test engineer shall also appreciate the possibility of the closure of existing leakage paths or the formation of new leakage paths resulting from the physical stressing of the item under test.

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*Basic environmental testing procedures for electronic and electrical items: Part XV Sealing test.

TABLE 1 VALUES OF *L* FOR DIFFERENT VALUES OF *V* AND θ

(*Clauses* 4.8.1 *and* 4.8.2)

θ		*V*	*L*
Nearest Value			
s	h	m³	Pa. m³/s
2×10^5	60	$0{\cdot}01 \times 10^{-6}$	5×10^{-9}
1×10^6	300	$0{\cdot}1 \times 10^{-6}$	1×10^{-8}
4×10^6	1 200	$0{\cdot}4 \times 10^{-6}$	1×10^{-8}
1×10^7	3 000	10×10^{-6}	1×10^{-7}
2×10^7	6 000	20×10^{-6}	1×10^{-7}

5. GUIDANCE TO BOMB PRESSURE TEST

5.1 Applicability of Test — This test is suitable for the detection of leak rates corresponding to an air leak rate greater than 10^{-6} Pa.m³/s. It is applicable only to items that are able to withstand external overpressure (*see* **5.2** and **5.3**).

5.2 This test is not recommended for use as a 100 percent inspection for the following reasons:

a) Ingress of the test liquid may not be detected at the time of test, but later may cause degradation or corrosion of the device (for example, passivated semiconductor devices); and

b) When an item is subjected to test liquid under pressure, moisture penetration tends to occur in areas not normally experienced in actual applications; this action may cause latent electrical degradations (for example, external leakage current).

This test may, however, be used on a sample basis for economic reasons, but only with full knowledge of the aforementioned risks.

The recovery period may be as long as two weeks, with periodic checks in the meantime, to make sure that these risks are kept to a minimum.

5.3 This test may be used with hermetically sealed components and parts when the Test Method 2 of Section 3 of IS : 9000 (Part XV)-1982* is not sensitive enough: moreover it can be carried out by less skilled personnel than Test Method 2 of Section 3 of IS : 9000 (Part XV)-1982*.

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*Basic environmental testing procedures for electronic and electrical items: Part XV Sealing test.

5.4 The duration of the conditioning may be reduced when the pressure is raised, but care should be taken that the applied pressure does not exceed the maximum value the item may withstand. A pressure of 250 kPa is sufficient for a number of applications.

An item that apparently passes this test may have been damaged by the pressure applied, particularly where it exhibits leaks that are too small to be detected by the electrical tests performed immediately after pressure release. In order to avoid errors, comparison measurements with reference items may be helpful.

5.5 The test liquid shall be able to produce detectable changes in the electrical characteristics of the item. Test liquids such as water or a mixture of water and alcohol are widely used. In each case, it should be verified that the test liquid does not react chemically with the surface of the item.

6. GUIDANCE TO SEALING TEST FOR EQUIPMENT

6.1 Applicability of Test — Procedures 1 and 2 are intended for ground and shipborne equipment; and Procedures 3, 4 and 5 are intended for airborne equipment.

6.2 Procedures 1 and 2 — The purpose of these test procedures is explained in Section 9 of IS : 9000 (Part XV)-1982*.

6.3 Procedure 3 — Excess Pressure Test

6.3.1 This test is applicable to equipment mounted within the pressurized zone of an aircraft, its purpose being to demonstrate that the equipment will not be deranged by positive air pressure applied when ground testing aircraft pressure cabins.

6.3.2 This test need only be applied to equipment having sealed enclosures (either pressurized or evacuated) or partially sealed enclosures having low leakage rates, which might be affected by an excess pressure condition.

6.4 Procedure 4 — Rapid Decompression Test

6.4.1 This test is applicable to equipment mounted within the pressurized zone of an aircraft. Its purpose is to demonstrate that, in the event of a pressurization supply failure or a structural failure of the aircraft causing a rapid but not explosive loss of pressurization, the equipment will survive or will fail in such a manner so as not to hazard the safety to the aircraft.

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*Basic environmental testing procedures for electronic and electrical items: Part XV Sealing test.

6.4.2 *Test Procedure*

6.4.2.1 The effects of pressure change only can be considered in the decompression phase of the test, for although temperature may change as a result of failure, such changes are unlikely to immediately influence equipment; furthermore, it is not practicable to reproduce a rapid temperature change simultaneously with the pressure change. If the effects of such temperature change are likely to be significant in the subsequent performance of the equipment, the temperature change to be applied will need to be stated in the relevant specification [*see* **5.4.7** of Section 9 of IS : 9000 (Part XV)-1982*].

6.4.2.2 It is expected that pressurization failure would be followed by descent of the aircraft to a more acceptable flight altitude; the very low air pressure following a failure would thus persist for a limited period only. If the effects of a descent to low altitude is significant to the equipment, the pressure changes to be applied will need to be stated in the relevant specification [*see* **5.4.7** of Section 9 IS : 9000 (Part XV)-1982*].

6.4.2.3 For aircraft with a large cabin volume descent may be initiated before all pressurization has been lost, and equipment would therefore be subjected to a pressure change less than that stated above. In such cases the requirements would need to be based on known or estimated characteristics of the particular aircraft.

6.4.2.4 The rate of change of pressure required by **5.4.5** of Section 9 of IS : 9000 (Part XV)-1982* may be difficult to achieve in most test chambers. For many items of equipment this rate of pressure change would not be significant and in such cases the relevant specification may relax the rate of change of pressure to that obtainable in the test chamber.

6.4.3 *Performance Evaluation*

6.4.3.1 In general the hazards resulting from rapid decompression may be defined as follows:

a) Physical break-up of an equipment interfering with either operation of adjacent equipment or any aircraft function; and

b) Loss of operation of equipment necessary for flight safety during and/or following a pressurization failure.

6.4.3.2 Equipment requiring only a demonstration of mechanical integrity need only be subjected to the test in its idle or inert state. For equipment where mechanical or electrical functioning is to be demonstrated, this equipment should be operated and the performance assessed at appropriate phases of the test.

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6.4.3.3 Equipment needing to operate without loss of function throughout the rapid decompression and subsequent phases should be brought into operation before the decompression phase is applied. In the case of heat generating equipment it may be required to allow the temperature of the equipment to re-stabilize before applying decompression [*see* **5.4.5** of Section 9 of IS : 9000 (Part XV)-1982*]. The performance of such equipment will need to be monitored throughout the test.

6.4.3.4 In the case of equipment required to function only following decompression, temporary derangement of the equipment at pressures corresponding to maximum flight altitudes may be acceptable, provided function is restored after descent to a more acceptable altitude.

6.4.3.5 Equipment operating intermittently in flight should be demonstrated in the operational or inert state, whichever is the more adverse.

6.5 Procedure 5 — Explosive Decompression Test

6.5.1 The purpose of this test is to demonstrate that, in the event of a structural failure of the aircraft causing an explosive loss of pressurization, such equipment will survive or will fail in a manner that does not hazard the safety of the aircraft.

6.5.2 *Test Procedure*

6.5.2.1 The effects of pressure change only can be considered in the decompression phase of the test, for although temperature may change as a result of failure, such changes are unlikely to immediately influence an equipment; furthermore it is not practicable to reproduce a rapid temperature change simultaneously with the pressure change. If the effects of such temperature change are likely to be significant in the subsequent performance of the equipment, the temperature change to be applied will need to be stated in the relevant specification [*see* **5.5.7** of Section 9 of IS : 9000 (Part XV)-1982*].

6.5.2.2 It is expected that pressurization failure would be followed by descent of the aircraft to a more acceptable flight altitude; the very low air pressure following failure would thus persist for a limited period only. If the effects of a descent to low altitude is significant to the equipment, the pressure changes to be applied will need to be stated in the relevant specification [*see* **5.5.7** of Section 9 of IS : 9000 (Part XV)-1982*].

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*Basic environmental testing procedures for electronic and electrical items: Part XV Sealing test.

6.5.3 *Performance Evaluation*

6.5.3.1 In general the hazards resulting from explosive decompression may be defined as follows:

a) Physical break-up of an equipment interfering with either operation of adjacent equipment or any aircraft function; and

b) Loss of operation of equipment necessary for flight safety during and/or following a pressurization failure.

6.5.3.2 Equipment requiring only a demonstration of mechanical integrity need only be subjected to the test in its idle or inert state. For equipment where mechanical or electrical functioning is to be demonstrated, this equipment should be made to operate and the performance assessed at appropriate phases of the test.

6.5.3.3 Equipment needing to operate without loss of function throughout the explosive decompression and subsequent phases, should be brought into operation before the decompression phase is applied. In the case of heat generating equipment it may be required to allow the temperature of the equipment to re-stabilize before applying decompression [*see* **5.5.5** of Section 9 of IS : 9000 (Part XV)-1982*]. The performance of such equipment will need to be monitored throughout the test.

6.5.3.4 In the case of equipment required to function only following decompression, temporary derangement of the equipment at pressures corresponding to maximum flight altitudes may be acceptable, provided function is restored after descent to a more acceptable altitude.

6.5.3.5 Equipment operating intermittently in flight should be demonstrated in the operational or inert state, whichever is the more adverse.

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*Basic environmental testing procedures for electronic and electrical items: **Part XV** Sealing test.